

**Integrated Risk Management
Within NASA Programs/Projects**

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Abstract

As NASA Project Risk Management activities continue to evolve, the need to successfully integrate risk management processes across the life cycle, between functional disciplines, stakeholders, various management policies, and within cost, schedule and performance requirements/constraints become more evident and important. Today's programs and projects are complex undertakings that include a myriad of processes, tools, techniques, management arrangements and other variables all of which must function together in order to achieve mission success. The perception and impact of risk may vary significantly among stakeholders and may influence decisions that may have unintended consequences on the project during a future phase of the life cycle. In these cases, risks may be unintentionally and/or arbitrarily transferred to others without the benefit of a comprehensive systemic risk assessment. Integrating risk across people, processes, and project requirements/constraints serves to enhance decisions, strengthen communication pathways, and reinforce the ability of the project team to identify and manage risks across the broad spectrum of project management responsibilities. The ability to identify risks in all areas of project management increases the likelihood a project will identify significant issues before they become problems and allows projects to make effective and efficient use of shrinking resources. By getting a total team integrated risk effort, applying a disciplined and rigorous process, along with understanding project requirements/constraints provides the opportunity for more effective risk management. Applying an integrated approach to risk management makes it possible to do a better job

at balancing safety, cost, schedule, operational performance and other elements of risk.

This paper will examine how people, processes, and project requirements/constraints can be integrated across the project lifecycle for better risk management and ultimately improve the chances for mission success.

Introduction

Risk Management has always been a part of the NASA management culture. However, in recent years the management of risk has taken on a more heightened level of importance. It has been a hot topic, especially in the Aerospace industry where more often than not it has been relegated to safety and hazardous circumstances. Although this perspective is very real and relevant, contemporary risk management must include many other aspects of the project such as cost, schedule, politics, parts, test, staffing, organizational factors, and other elements that could potentially lead to a failure in delivering projects within cost, schedule and operational requirements/constraints. This perspective has to be taken because of the complexities and interdependencies associated with many of today's projects. As a means to manage all project risk it is imperative to approach risk management in an integrated, systematic, and disciplined manner so that the important risks are identified, resourced properly, and mitigated to an acceptable risk level. Integrated risk management brings together engineering and project management processes, along with all the stakeholders such as contractors, supplies, partners, academia and others as a resource to help decision makers make better decisions. This kind of risk management provides the systemic and

The People part of Integrated Risk Management

Most NASA projects are complex and involve many internal and external organizations. The people part of integrated risk management will address how to get the internal as well as the external organizations to work with one another in performing project risk management. Most projects unknowingly start with weak risk management requirements. They have poor agreements, contractual arrangements and management commitment. At best, they end up doing a decent job at running down problems and reacting to short-term risk. They start the project with good intentions but create a stovepipe risk management process that has each stakeholder off doing their own risk management activity instead of working with one another. The project essentially ends up with the government team, the contractor team, suppliers, partners, and other stakeholders doing their own independent risk management activity without talking to one another until there is a real problem. This process has the illusion of integrated risk management but doesn't carry the same punch. This type of management is reactive and detrimental to risk management. It tends to eventually overshadow risk management and push it to the back burner. Many managers must get away from the notion that "there are-my risks" and "there-are-your-risks" because if any one part of the team fails the entire project could fail. The people part of integrated risk management deals with all the stakeholders on the project and how they can be used as a resource to provide the best information for decision makers. Integrated risk management looks at all the stakeholders as an integrated product team. The philosophy removes the "us- and- them" mentality and breeds an overall one-team "Big-us" mentality that cherishes open communication and discussion about all project risk. Using the rich diversity of people and their expertise and knowledge on the project provides an opportunity to see a very healthy dialogue that makes for a better understanding of the risk likelihood and impact. In any project

management endeavor people are involved and one must consider their role in the risk management activity. This must be done from the individual level, and the functional organizational level. How a project is organized and how the different functional disciplines work with one another must be considered as a vital part of risk management. Systems engineering, systems assurance management, procurement management, financial management, project management, and executive management personnel are just a few of the disciplines that must be considered in the risk management activity. Organizationally the project risk management activity must consider the prime contractor, partners, other agencies, suppliers, academia, and other stakeholders on the project outside of the immediate government project team.

All stakeholders have unique characteristics, strengths and weaknesses, resources and requirements/constraints, which can compliment and/or hamper risk management activity. The government project team is provided requirements, resources and given limits and deadlines which must be met. Into this environment come prime contractors and partners who must interact with the government team and understand and accommodate government requirements regarding such things as safety and risk management, and reconcile these requirements with their own internal processes in order to effectively deal and communicate with the government team and their partners. Involving other agencies further complicates the environment because integrating processes can be hampered by language barriers, differences in systems of measurement, cultural and political complexities, time zones and physical distances to name but a few. Risk management and the integration of risk management processes become even more important in this complex environment. The integration of risk management creates a network of communication common to all team members that can be used to identify, track and manage project risks regardless of source or location.

disciplined level of management required in NASA projects today to meet mission success. This deliberate activity improves the chances of project mission success by surfacing risks that would perhaps get over looked, missed or improperly handled.

Applying integrated risk management across the project provides the project team with the best chance at identifying risks that are important for mission success. By using the people, process, and project requirements/constraints integrated risk approach projects allow the entire team to get involved in identifying risk, applying discipline to the process, and understanding the acceptable project risk. Figure-1 illustrates integrated risk management across the project life cycle. This figure represents how the people, processes, and project requirements/constraints are an integral part of the Risk integration process. This figure represents the people, both organizationally and functionally that must be considered and integrated within the processes (System's Engineering processes, project management processes, and Continuous Risk Management processes) and it identifies project requirements/constraints such as cost, schedule, performance, and safety.

At NASA projects are required to follow NASA Policy Requirements (NPR). NPR 7120.5 and NPR 8000.4 provide the requirements for project management and risk management respectively. The NASA systems engineering guidebook 6105 although not a requirement, is an important best practices reference that discusses the importance of good systems engineering and how risk management is an important part of Systems Engineering. Projects are required to follow 7120.5 because it provides a minimum set of requirements a project must perform to be successful and to manage risk. NPR 8000.4 provides requirements for a disciplined and rigorous Continuous Risk Management Process and explains that this process should be an integral part of project management.

The remainder of this paper will discuss each risk integration element (people, process and project requirements/constraints) and how they are integrated and applied to project risk management in the integrated risk management concept.

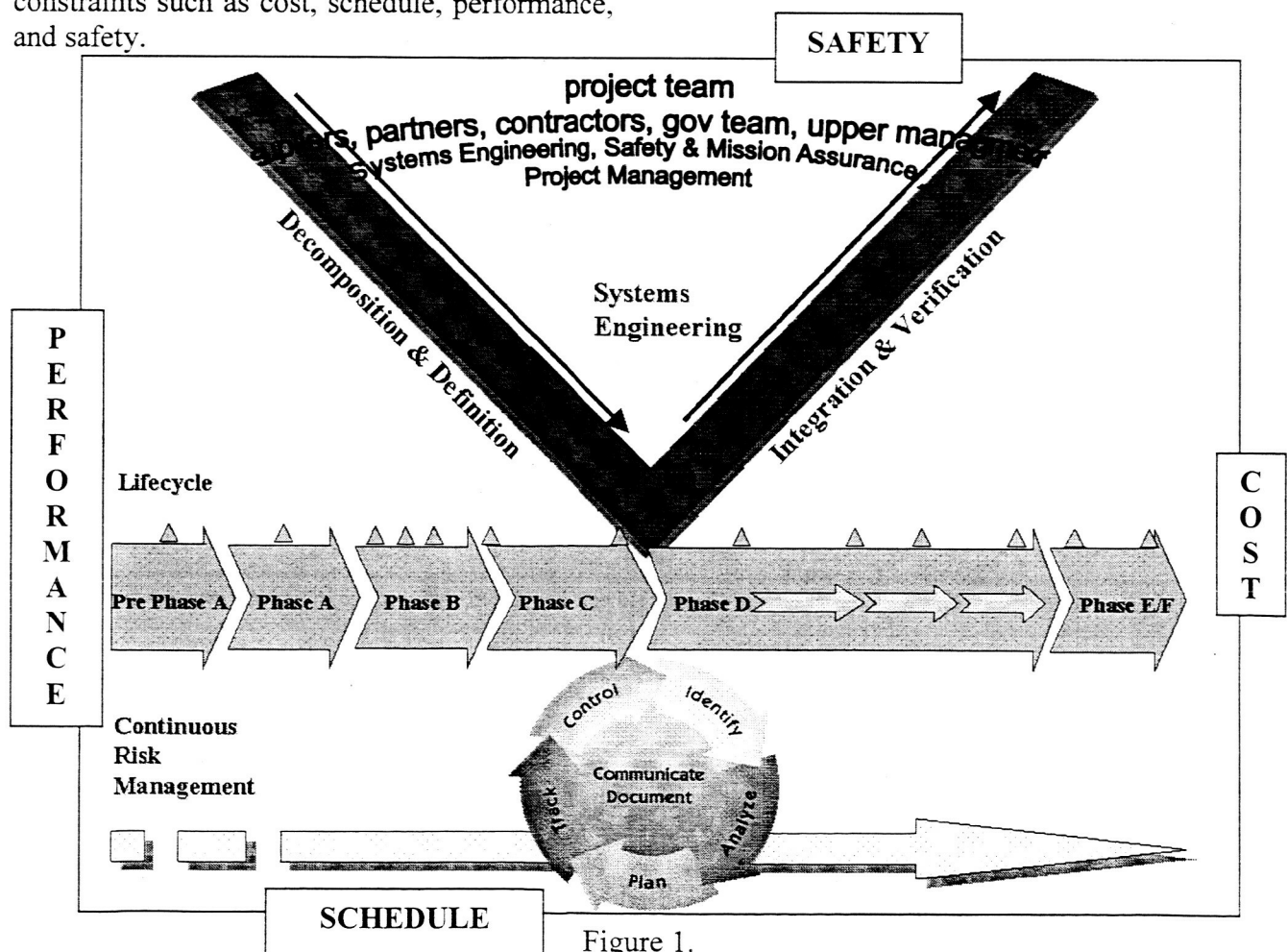


Figure 1.

Figure 2 shows that it must be recognized that everyone involved in the program or project must be a part of the risk management activity and integrated as one whole system. Suppliers, academia, and all other members of the program/project team must be a part of and support the risk management effort. All stakeholders must understand the process, their role in the process, and most importantly of all... the ultimate goal of the project, mission success.

schedule slip?", etc. The second key member is the "Subject Matter Expert". This member provides the detailed knowledge and experience in the technology, operations, or process to be assessed. This member is the "optimist" asking the question "How will this be accomplished successfully? "How does it work?", "How much time and money will it take?". The third member is the "Decision-Maker". This team member takes on the role of the "pragmatist" asking the question "Is it acceptable?", "What is

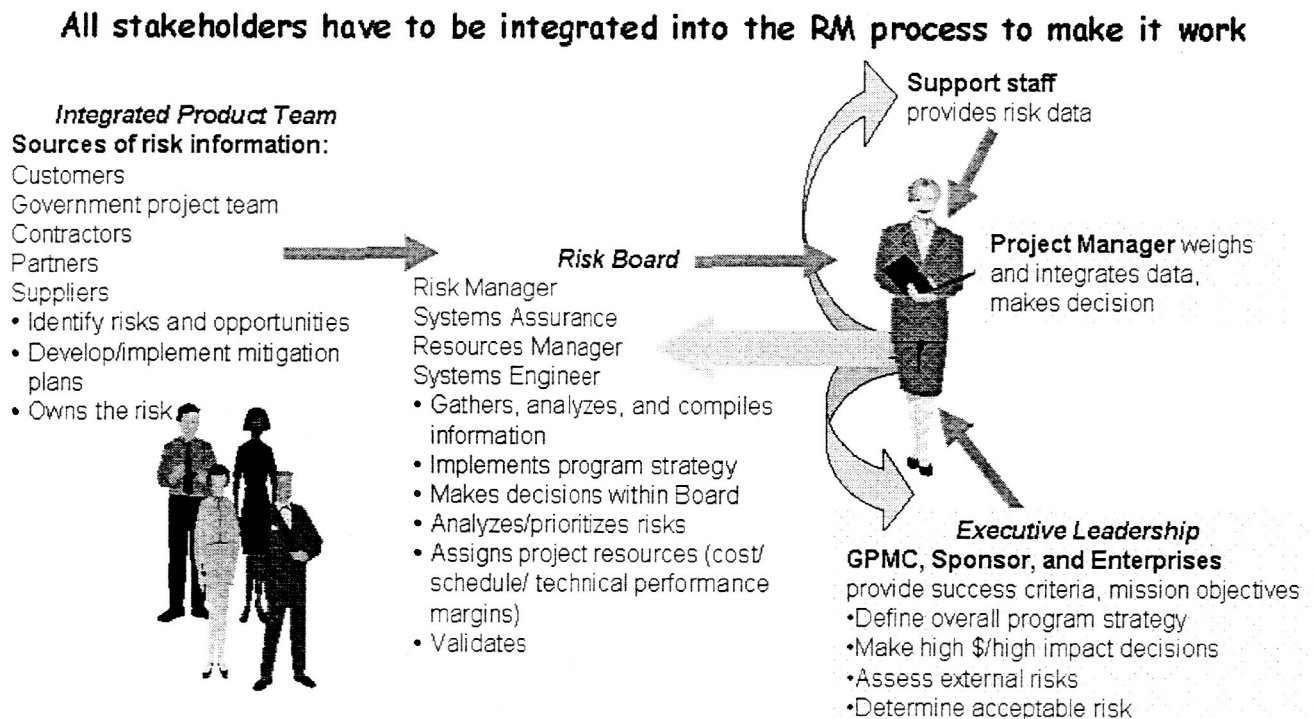


Figure 2.

The team approach is a significant element to a successful integrated risk management approach. A successful team should always be made of three key team members representing these three functions. The first is the Practitioner/Analyst. This member provides detailed experience in the use and application of the tools & techniques used to identify and analyze the potential risks. The Practitioner/Analyst is the "skeptic" asking questions such as "How can it fail?", "What is the weak link in the integration and test process?", "Do these trends indicated a critical

good enough given the constraints", "Will this option provide the technical performance that is needed within the cost and scheduled constraints imposed? These functional areas are very often represented as follows: the Practitioner/Analyst represented by Safety, Reliability & Mission Assurance; the Subject Matter Expert represented by Systems Engineering/Designers & Developers; and, the Decision-Maker represented by Program/Project Management. It is important to understand that these functional roles are dynamic and shift from organizational group to organizational group based on the risk

being managed. For example when considering cost or schedule necessary to support the quality control of a critical fabrication process, the role Practitioner/Analyst may be represented by a budget analyst or scheduler in Program/Project Management. In this case the role of "Subject Matter Expert" is provided by the Quality Control Engineer. With the role of "Decision-Maker" taken up by the Systems Engineer or some other technical expert in the field.

The NASA Goddard Space Flight Center (GSFC) Microwave Anisotropy Probe (MAP) Project provides a vivid example of how integrated risk management may be implemented for a spacecraft design and development project. As described by the MAP Mission Systems Engineer, ("The Systems Engineering Approach to Risk Management & Reliability on the MAP Project", Michael Bay, Jackson & Tull, Aerospace Division supporting the NASA GSFC Systems Management Office, NASA risk Management Colloquium III, September 18, 2002) the MAP Project included the entire project team in understanding how to implement an integrated risk management process by asking the following requirements/constraints related questions: "What makes a mission successful?" and "What makes a mission unsuccessful?". Throughout the design and development process the MAP Project effectively applied project management, systems engineering, and mission assurance techniques in order to achieve a balance between requirements and constraints and between immediate, short-term risk mitigation vs. long-term mission success objectives.

A key strategy used by the MAP Project was to integrate risks in terms of the collective impacts on safety, on-orbit technical performance, and project execution. This allowed the team to clearly address trades and risk mitigations with a an increased insight into the ultimate consequence avoiding the common pitfall of misunderstanding the what is truly a requirement and what is truly a constraint. A detailed set of criteria where established defining safety risks, acceptable mission risks, and acceptable development risks. These criteria were applied collectively in every case

and for every risk in the risk management process to ensure that a comprehensive risk profile/risk exposure was defined.

Integrated Risk Management Using Systems Engineering (SE), Safety and Mission Assurance (SMA)

The SMA function is a vital part of the risk management team. The SMA assures that quality, safety, reliability, and risks are at acceptable levels before the next major phase of the project is attempted. Safety engineering and reliability engineering use functional policies and processes to identify and categorize risk. This also applies to other disciplines in management that track cost and schedule risk on the project.

There is a definite overlap between safety, reliability, quality/mission assurance and risk management. Safety is focused on events and conditions that can cause injury or damage, reliability is focused on system performance failures or malfunctions, quality/mission assurance ensuring that the processes used are effectively communicated, documented, and controlled. When integrated each element plays a vital role in supporting the risk management process.

There is a natural synergy among the main elements of a reliability program, a system safety program, and quality assurance program. A variety of techniques and methodologies fit together to achieve an effective integrated risk management process. These are predominately used in system safety and reliability to identify and analyze potential risks to a project or program.

Quality/Mission Assurance provide a comprehensive approach for integrating these and other systems engineering elements by reviewing all necessary inputs, including policy documents, plans, specifications and contracts, to gain a full understanding of overall mission or system requirements. Quality/Mission Assurance ensures that documentation and continuous communication for the full life cycle are maintained among all of management, engineering, assurance, safety, and reliability disciplines. Often Quality/Mission Assurance

provide the management support and services as the focal point for developing a tailored System Safety, Reliability, and Quality Assurance Program Plan in accordance with established policies, requirements, and guidelines.

As the project proceeds through the life cycle, design reviews and testing are supported, analyses are updated to reflect changes and verification tracking through log/matrices are checked to ensure compliance including the following activities:

- Evaluating changes that impact a reliability prediction working closely with the project management, systems engineering and reliability/safety to recommend design improvements that maintain or improve baseline technical performance.
- Participating in reviews,
- Monitoring performance metrics throughout the process and recommend improvements,
- Monitoring Validation & Verification activities,
- Performing audits and vendor surveillance to verify conformance
- Establishing contract requirements for the project during phase-A of lifecycle

This comprehensive approach allows early identification of potential problems (i.e., risks), so that they can be corrected to increase the likelihood of mission success. For example, detailed information from the Failure Mode and Effects Analysis, Failure Modes and Effects Criticality Analysis, and reliability predictions are used by the system safety engineers to help identify and categorize hazards and to determine failure probabilities. Likewise, design changes incorporated to enhance safety must be evaluated to update reliability, availability and risk assessments by reliability engineering. Quality/Mission assurance support both safety and reliability by tracking the effectiveness of the design changes and other measures used to mitigate potential risk and by providing structured & disciplined methods for documenting and communicating the status of

these activities. Although often considered to be a separate processes integrating safety, reliability, and quality assurance ensures a comprehensive approach to managing risk.

The process Part of integrated risk management

The process part of risk integration ties in the project life cycle process from phase-A through phase-E, continuous risk management process, Safety and Missions Assurance Process, and the systems engineering process, as described by NPRs 7120.4 and 8004, NPD 8700.1, and NASA SE handbook 6105 respectively.

NASA has a policy that all NASA Programs and Projects consider risk when conducting day-to-day operations and that risk management be a part of all planning and decision-making. All Programs and Projects are required to have a Risk Management Plan and to create and maintain a Risk List in order to help capture their risks and track their risk mitigation efforts. NASA policy also identifies a continuous risk management (CRM) process. NASA adopted the CRM process in 1995 and a systems level course was developed for risk management that provides information on risk management implementation. This course was developed in a collaborative effort with the Software Engineering Institute at Carnegie Mellon University, and tailored to the NASA community. Since its inception, the CRM course has been presented more than 200 times to NASA Programs and Projects and to government organizations external to NASA as well. Figure 3 depicts the Continuous Risk Management process as a wheel, representing the continuous, iterative nature of risk management.

The five steps of the process, Identify, Analyze, Plan, Track and Control surround the central theme of Communicate and document... the key to successful risk management. By maintaining good internal and external communication pathways and by integrating risk management seamlessly into the Program/Project infrastructure we can enhance performance and increase mission success.

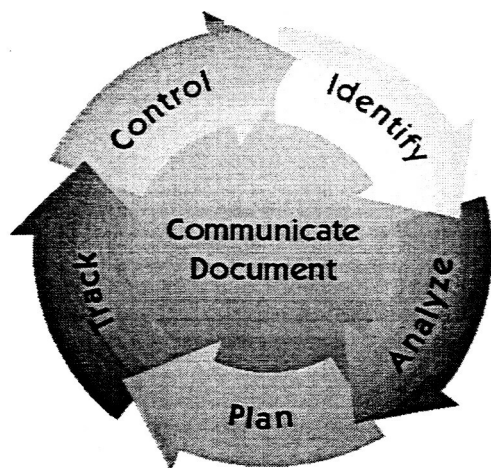


Figure 3.

The relationship between the risk management process and other processes such as the Systems Engineering process, Safety and Mission Assurance process, and the Program/Project Management process is symbiotic. Each of these processes exists separately and can perform its functions on its own but when combined, when integrated with one another they become greater than the sum of their parts. Each process benefits from and feeds each of the other processes, complimenting each and providing each process with added insight and awareness that provides decision makers with a much clearer understanding of the health of their project.

Figure 4 depicts the continuous risk management flow process, demonstrating inputs and outputs at each of the five stages. Although risk management begins early in formulation it should be understood that the process continues and is a part of the project from the cradle to the grave.

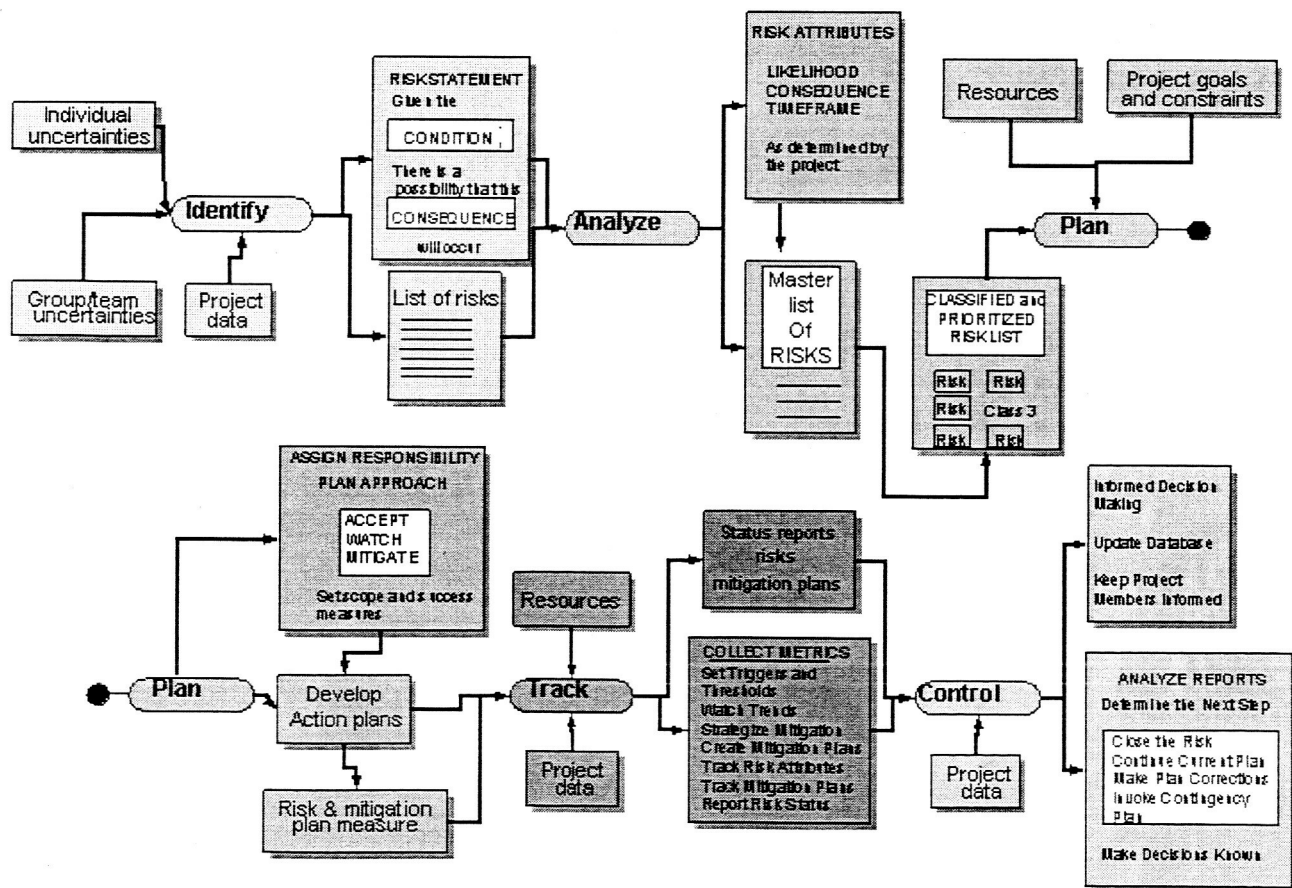


Figure 4.

Starting Risk management early in the lifecycle (Risk management in acquisition):

Starting risk management early in the life cycle has tremendous benefits to the project. An early start lays the foundation for how you will manage risk for the entire program/project life cycle. The Risk based acquisition management (RBAM) process is a fundamental part of risk management and is in the NPR 7120.5b. RBAM helps identify acquisition risk and provide decision makers with information that allows them to see Risk information relative to the source selection of a prime contractor. The other benefit of RBAM is that it allows the project to establish risk based surveillance requirements along with award fee and contract incentives based on assessed contract risk. Figure 5 shows the RBAM process. RBAM is integrated with the CRM process at the very early stages of the project. Prior to contract award the RBAM process helps identify contract risk so decision makers can analyze, plan, track, and mitigate those risk before they become problems. RBAM serves as a means to let managers know what information should go in the contract prior to contract award.

RBAM serves as an integration process to get SE, SMA, Resource management, and Project management information in the contract prior to contract award. What goes into the contract sets the tone for how RM is to be performed throughout the project lifecycle.

The project requirements/constraints part of integrated risk management

The project requirements/constraints part of risk management obviously takes into consideration the requirements and constraints associated with cost, schedule, safety and technical performance.

The risk management process is in itself the glue that binds the three pivotal disciplines. In general risk management considers risks that integrate the following three characteristics: technical, cost, and scheduled. All too often the focus is on just a single characteristic with little consideration given to integrating and balancing the risk with the other characteristics. As an example, the consequences and mitigations for a technical risk are often limited to addressing the technical issue at hand with the other characteristics of risk viewed as constraints.

RBAM Process

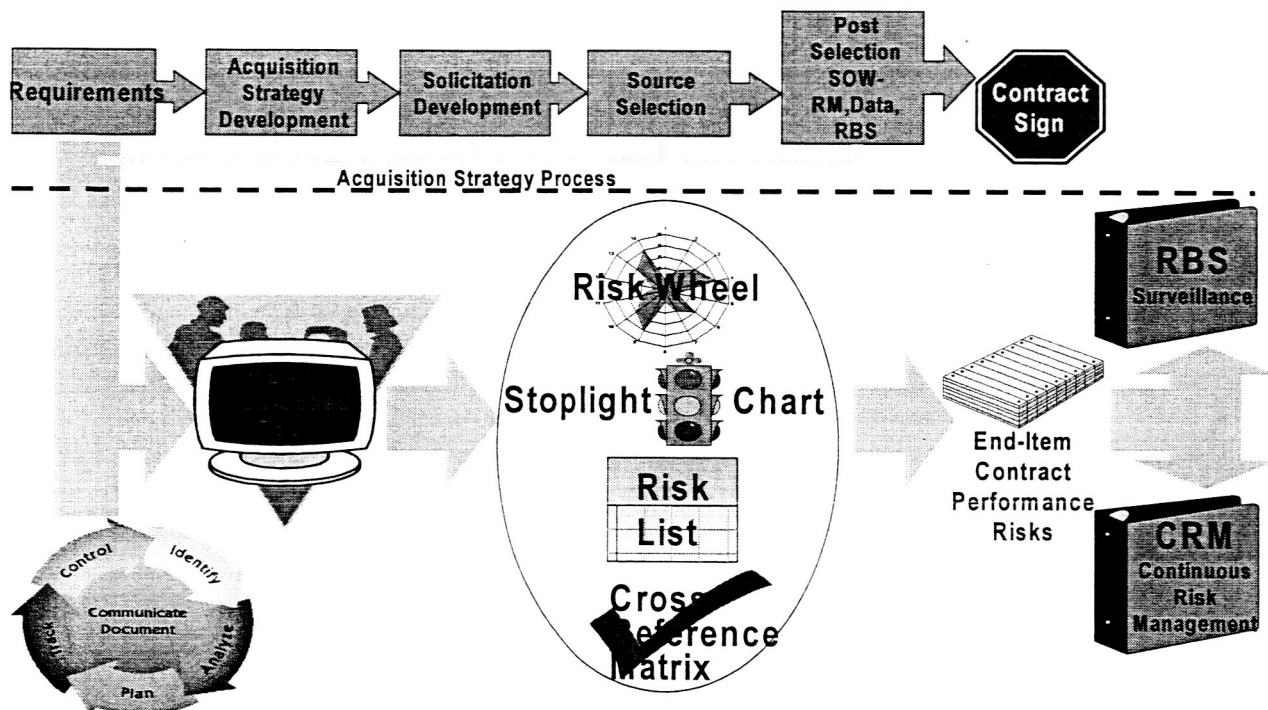


Figure 5.

That is to say: the engineering will for the most part address the details related to the identification, analysis, and mitigation of the technical aspects of the risks. All the while looking at the other characteristics of risks, not as integrated elements of the same risk, but as constraints either as a contributing factor in creating the original risk or as a limit to the level of mitigation possible.

In the integrated approach to risk management all of the relevant characteristics must be evaluated in a balanced way when identifying, analyzing, and mitigating risk. Should the project manager spend a \$1M to achieve the technical performance within the allocated schedule; or should the project manager reduce the technical requirements in favor of maintaining the budget and schedule?

When considering the potential risk impact technical, cost, and schedule are generally identified. Similarly, risks are often identified in terms of technical, cost, and schedule. Risks are most affectively dealt with when technical, cost, and schedule are viewed as inherent characteristics of all risks integrated across the entire spectrum of impacts. This perspective allows for the identification, analysis, and ultimately mitigation of risks in a balanced and integrated manner. Ensuring that all aspects of the risks are evaluated and appropriately mitigated.

Perspective plays a significant role in risk management. "One person's risk is another person's constraint". Consider for a moment the traditional segregated process for risk identification, analysis, and mitigation. In this traditional approach, the engineer considers all the potential technological, design, and testing risks in achieving a particular technical performance. The project scheduler considers all the schedule slips, the slack, the variances between planned and actual schedule dates, and critical path risks in maintaining a particular schedule. The resource manager similarly considers risks in terms of personnel, cost, and other types of resources. In each case, the given risk perspective often considers the other elements as constraints to either achieving the objective or as a constraint to fully mitigating a

given risk. So the engineer's perspective may state as "any technical performance can be achieved given enough time and money".

The integration of risk across these disciplines and across the lifecycle has been accomplished as an example on the MAP Project at the Goddard Space Flight Center. Current examples of this integration and balancing are evidenced by the current implementation of Risk Management on the Global Precipitation Management (GPM), and Solar Dynamics Observatory (SDO) projects, and James Webb Space Telescope (JWST) program. The JWST program is an example of this integration across larger organizations. GPM and SDO are examples of integration across disciplines using a balanced approach to mitigate risks. The JWST program provides a good example of integration across multiple organization and multiple functional tiers.

Summary:

Integrated Risk management is a disciplined and deliberate risk management activity that involves a systemic approach and covers the entire project life cycle. It primarily involves the people, process, and project requirements/constraints of the project. The primary benefit of risk integration is it gets all of the stakeholders involved in the process and creates communication and dialogue among team members who would otherwise not communicate with one another. It forces leaders to report and identify acceptable risk, and allows the project manager to make more informed decisions. Integrated risk management is not a discipline in and of itself but a part of all management activity including project management, systems engineering management, and functional management (safety, reliability, etc.). All stakeholders must be involved in risk management to be successful. The process part deals with understanding policy requirements and applying them in a way that benefits the project. The process also involves the understanding of roles and responsibilities of all the stakeholders on the project team.

References:

NPR 7120.5 Program and Project Management Processes and Requirements

NPR 8000.4 Risk Management Procedures and Guidelines

NPD 8700.1 NASA Policy for Safety and Mission Assurance

NPR 8715.3 NASA Safety Manual

NASA Systems Engineering Guide 6105, dated 1995

Carnegie Mellon University Software Engineering Institute CRM guidebook, 1996

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